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(54) **Device and dispersion for intrapulmonary delivery of polypeptide growth factors and cytokines.**

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Description

This invention relates to the administration of proteins by adsorption from the lungs. In particular, it is concerned with providing therapeutic, sustained doses of growth hormones or cytokines to the bloodstream without irritating or otherwise damaging lung tissues.

Drug delivery by pulmonary absorption from particles such as aerosols has met with considerable success in several instances of localized delivery to lungs as the drug target tissue, most notably the use of beta adrenergic antagonists in the treatment of asthma. Other drugs that have been administered in this fashion include corticosteroids and cromolyn sodium. On the other hand, the administration of aminoglycoside antibiotics, antiviral drugs and anti-cancer drugs for systemic action by this route has only met with spotty success. In some cases, lack of delivery to the blood stream was attributed to inability of the drug to pass through the alveolar epithelium. In other cases the drug was found to be irritating and bronchoconstrictive (Juliano, 1984, "Pharm. Ther.", 24:355-365). At this time it is not possible to reasonably predict in advance that any given drug will be nonirritating or will be adsorbed through the lungs in an amount sufficient to be therapeutically useful.

Similarly, extensive studies have been conducted on the pulmonary absorption of proteins and polypeptides. While size, lipophobicity, and possibly other poorly characterized features of such molecules appear to create a substantial barrier to their absorption into the blood stream (Juliano, op cit; Egan, 1983, "Am. Rev. Resp. Dis." 127(5) Pt. 2 537-539; Hogg et al., 1979, "Fed. Proc." 38(2):197-201), there remains considerable disagreement about protein permeability from the alveoli into the blood under ordinary conditions. For example, studies with albumin or horse radish peroxidase (HRP) are illustrative.

Dominguez et al. "Lab. Invest." 16(6):905 [1967] observe that the alveolar wall is only "slightly permeable" to albumin. Similarly, earlier workers found no pulmonary absorption of homologous plasma albumin at all (Drinker et al., 1947 "J. Exp. Med." 86:7), while others demonstrated absorption of albumin only from lung subsections hyperinflated in excess of 40 cm H_2O pressure; the same pressure applied to the total lung did not produce protein permeability (Egan et al., 1982, "J. Appl. Physiol." 53:121). Newborn lambs were found to be capable of pulmonary albumin absorption, but only for a brief period postpartum (Egan et al., 1984, "Ped. Res." 18(6):566). Finally, Bensch et al. ("Science" 157:1204-1206 [1967]) report the rapid absorption of instilled solutions of radioactively labelled albumin or gamma globulin across the pulmonary air-tissue barrier. More than two thirds of the administered polypeptides could be accounted for in the blood of the test animals after 24 hours. These authors also report the work of others (Drinker et al., op cit) to the effect that removal of lower molecular weight proteins from the lumin of the alveoli occurs only after degradation of the molecules, notwithstanding that Bensch et al. did not detect degradation of albumin or gamma globulin.

Bensch et al. ("Yale J. Biol. Med." 43:236-241 [1971]) later observed (based on similar studies with HRP) that macromolecules may cross the air-blood barrier by being transported directly into the pulmonary capillary blood in the pinocytotic vesicles of the membranous pneumocyte and endothelial cells. However, the Bensch et al. experiments were conducted by installing HRP into the lungs in the form of an aqueous solution.

Conner et al. ("Fundamental and Appl. Toxicology" 5:99-104 [1985]) instilled a solution of HRP into the trachea of experimental animals after exposure to zinc oxide particles, suggesting that absorption of this protein was a function of pathological effects by zinc oxide. This was consistent with the report by Hogg et al., op cit. that the bronchial epithelium is normally nonpermeable to proteins unless damaged in some way, such as by cigarette smoke, ether, antigens, histamine, or methacholine.

Other polypeptide probes besides albumin, gamma globulin and HRP have been used in the study of pulmonary absorption. These include microperoxidase, equine cytochrome c, equine myoglobin, bovine lactoperoxidase and human myeloperoxidase (Schneeberger, 1978, "Fed. Proc." 37(11):2471), superoxide dismutase or catalase (Padmanabhan et al., 1985, "Am. Rev. Respir. Dis." 132 (1):164-167), and ferritin (Richardson et al., 1976, "Lab. Invest." 35(4):307). None of these agents, however, has been employed in a systemic therapeutic context, i.e. delivered in the expectation of achieving a therapeutic dosage at a desired site distal from the lungs per se.

U.S. Patent 4,476,116 proposes delivering human growth hormone or interferon by intranasal absorption of a nasal spray containing the protein and a chelating agent. Since particles of 5 μm or greater are removed in the nasopharyngeal region (Juliano et al.) It must be concluded that an effective nasal spray would contain aerosol particles having at least this mean diameter. Similarly, EP 122036 describes a powdered composition for intranasal administration of growth hormone or interferon wherein at least 90% of the particles had an effective diameter of 10 to 250 Microns. The minimum diameter was established with the object to avoid introducing the particles into the lungs.

Intranasal administration of growth hormone or interferons is undesirable because of dosage variability, side effects such as nasal irritation, extremely poor polypeptide permeability into the blood stream and polypeptide degradation by normal nasal microorganisms. Of course, these polypeptides have been conventionally administered by injection or infusion. This delivery route suffers from obvious deficiencies, the most glaring being the requirement for regular growth hormone injections in children or, in the case of interferons being employed for the treatment of malignancies, an absence of a healthy vasculature for catheterisation of the patients. An improved method for the administration of these proteins is needed.

European patent application EP-A1-0 170 715 discloses an atomising apparatus intended to produce a high proportion of aerosol particles whose size lies between 0.5 and 5.5 µm. The apparatus disclosed is suitable for atomising powders and liquids. No details of the composition of the material to be atomised is given.

The present invention provides a method for delivering to the blood stream of a patient a therapeutic dose of polypeptide selected from growth factors and cytokines, which method comprises delivering a therapeutically effective dose of the polypeptide into the lungs of the patient. A device is provided for accomplishing this method that comprises reservoir means for storing the polypeptide; a therapeutic dosage form of the polypeptide disposed in the reservoir means; dispersing means for forming in a gas a suspension of particles comprising the polypeptide wherein the size of the particles is sufficiently small to permit their penetration into the alveoli of the patient's lungs upon inhalation; means for transporting the polypeptide to the dispersing means; and means for delivering the particle suspension to alveoli of the patient's lungs.

An advantage with respect to the delivery of therapeutic doses of these particular polypeptides is that they are delivered systemically by pulmonary absorption without pathological effects on the lungs or a requirement for an epithelial irritant or absorption enhancing agent such as ether, zinc oxide, antigens, histamine, methacholine, water soluble amphophilic steroids, bile salts such as sodium glycocholate, lower alkyl ethers of cellulose, chelating agents or water absorbing-water insoluble substances such as polyvinyl pyrrolidone, sodium carboxymethyl cellulose, polyacrylates and the like.

Figure 1 is a schematic depiction of a device for intrapulmonary delivery of a polypeptide aerosol.

Figure 2 depicts the serum hGH concentrations following fine aerosol intrapulmonary delivery of methionyl human growth hormone to an anesthetized baboon. Two doses of 60 mg each are shown as D1 and D2. Each dosing was terminated at the points designated "End D1" and "End D2". Serum growth hormone concentrations increased rapidly and additively after each administration.

Figures 3 and 4 shown the serum concentrations of human gamma interferon and tumor necrosis factor-α respectively after intratracheal instillation thereof into anesthetized rats. The intratracheal dose is shown below each graph.

The polypeptides to be delivered by intrapulmonary absorption are growth factors and cytokines. Growth factors or hormones are polypeptides that induce the proliferation or enlargement of target cells. Such factors are hormones, hereafter referred to as hormones for convenience, may incidentally increase the respiratory rate or metabolism of the target cells, but in the absence of increased cell mitosis or enlargement a polypeptide is not to be considered a growth hormone for the purposes of this application. Most growth hormones exhibit a molecular weight of about from 5 kD to 75 kD and a pI ranging from about 4 to 8. Specific examples include growth hormone (somatropin), thymosin, somatomedins such as IGF-1 or IGF-2, transforming growth factors-α and β, nerve growth factor, platelet-derived growth factor, ovarian growth factor, fibroblast growth factor, myoblast growth factor, epidermal growth factor and the like, but excluding insulin. These substances are well known to those skilled in the art and, in many cases, have been cloned and expressed in recombinant organisms. The preferred growth hormone for use herein is somatropin or its N-terminal methionylated variant (somatrem) described below.

Cytokines are the polypeptide secretory products of cells constituting the immune system, e.g. lymphocytes such as B-cells and T cells, including helper and suppressor T cells, macrophages and neutrophils. Cytokines serve as effectors in that they induce changes in the activity or secretory products of other immune cells, or a direct acting proteins in that they induce a change in a target non-immune cell. Furthermore, many cytokines, e.g. thymosin or gamma interferon, may be considered growth hormones as well in that they induce the proliferation of specialized immune target cells. Typically, cytokines have molecular weights of about from 5 kD to 30 kD and pI of about from 4 to 8. Examples of cytokines include the interleukins, tumor necrosis factors, interferons and immune suppressor factors. Preferred cytokines for use herein are tumor necrosis factors -α and β, and interferons-α, β and γ.

The terms growth hormone and cytokine are to be considered to include amino acid sequence, glycosylation and other variants of the native molecules. These variants may exhibit enhanced levels of the normal biological activity of the native molecules or may, on the contrary, act antagonistically towards the native molecule. Alternatively, variant are selected for improved characteristics such as stability to oxidation, extended biological half-life, and the like. Such variants as are known or will be developed in the future are suitable for use herein. For example, N-terminal methionyl human growth hormone (somatrem) is an example of a common variant produced in recombinant cell culture wherein a methionine residue not found in the native analogue is covalently bound to the normai N-terminal amino acid residue.

The polypeptides administered in accordance with this invention are first placed into a particulate dispersed form. This is accomplished by preparing an aqueous aerosol or solid particles which contain the polypeptide. Ordinarily, an aqueous aerosol is made by formulating an aqueous solution or suspension of the desired polypeptide together with conventional pharmaceutically acceptable carriers and stabilizers. The carriers and stabilizers will vary depending upon the requirements for each polypeptide, but typically include nonionic surfactants (Tweens, Pluronics or polyethylene glycol), innocuous proteins like serum albumin, sorbitan esters, oleic acid, lecithin, amino acids such as glycine, buffers, salts, sugars or sugar alcohols. The formulations also can include mucolytic agents such as those described in U.S. Patent 4,132,803, as well as bronchodilating agents. The formulations will be sterile. Aerosols generally will be prepared from isotonic solutions. The particles optionally include normal lung surfactant proteins.

It is within the scope of this invention to form aerosols of particles in aqueous or nonaqueous, e.g. fluorocarbon propellant, suspension. Such particles include, for example, intramolecular aggregates of the polypeptides or liposomal or microcapsular-entrapped polypeptides. The aerosols should be free of lung irritants, i.e. substances which cause acute bronchoconstriction, coughing, pulmonary edema or tissue destruction. However, nonirritating absorption enhancing agents are suitable for use herein. The dispersing means may be means for hydraulic atomization or for ultrasonic dispersion.

Sonic nebulizers preferably are used in preparing aerosols. Sonic nebulizers minimize exposing the polypeptides to shear which can result in degradation of the molecule. A suitable device is the Bird Micronebulizer. However, it is also within the scope of this invention to employ other atomizing or nebulizing systems or intratracheal delivery systems, e.g. U.S. 3,915,165, the aerosol generator-inhalator described in EP 166476, the jet nebulizers described by Newman et al. "Thorax" 40(9):671-676 (1985), metered dose inhalers (M. Berenberg, 1985, "J. Asthma-USA" 22(2):87-92), or other devices (Sears et al., 1983 "N.Z. Med. J." 96:743II; O'Reilly et al., 1983, "Br. Med J." 286:6377; or J. Stander et al., 1982, "Respiration" 44(3):237-240), so long as they are compatible with the protein to be administered and are capable of delivering particles of the desired size.

Particulate aerosol suspensions are essentially fine dry powders containing the polypeptides. They are prepared by any number of conventional procedures. The simplest method of producing them is to micronize polypeptide, e.g. crystals or lyophilization cakes, and suspend the particles in dry fluorocarbon propellants. In these formulations the polypeptides do not dissolve in the hydrophobic propellants (which evaporate after the suspension is released from the pressurized device into the air). Rather, the polypeptides are suspended in the fluorocarbon. In an alternate embodiment the polypeptides are stored in a compartment separate from the propellant. Discharge of the propellant withdraws a predetermined dose from the storage compartment. The devices used to deliver drugs in this manner are known as metered dose inhalers (MDIs) (P.R. Byron, 1986, "Drug Development and Industrial Pharmacy" 12:993).

The size of the aerosols or particles generally will range about from 0.5 μm to 4 μm, preferably about 0.5 to 1 μm. Smaller particles are less acceptable because they tend not to be deposited but instead are exhaled. Larger particles are not preferred because in large measure are unable to be deposited at the level of the alveoli, being removed by impaction within the nasopharyngeal or oral cavities (Byron, 1986, "J. Pharm. Sci." 75:433). Obviously, most aerosol or particulate compositions will be heterogenous in size distribution, although heterogeneity can be reduced by known methods, e.g. the screening unit described in EP 135390A. Heterogeneity will not be disadvantageous unless the proportion of particles having an average mean diameter in excess of about 4 μm is so large as to impair the delivery of a therapeutic dose by pulmonary inhalation. Suspensions containing greater than about 15% of particles within the 0.5-4μm range can be used, but generally the proportion of particles having an average mean diameter larger than 4 μm should be less than about 25%, and preferably not greater than 10%, of the total number of particles. The diameters recited refer to the particle diameters as introduced into the respiratory tract.

The particles may or may not bear a net charge. The presence of a net charge is desirable for minimizing particle aggregation in the airways since the particles will repel one another electrostatically. Charged particles are made by removing water from solutions of the polypeptides at a pH other than the isoelectric point, e.g. ordinarily about from 0.5 to 2 pH units on either side of the isoelectric point. On the other hand, dewatering of polypeptides at a pH other than the isoelectric point may result in precipitation or denaturation of the protein, so the desirability of use of such a pH will depend upon the known characteristics of the polypeptide to be administered.

A suitable system for inhalation delivery of the polypeptides herein is illustrated in Fig. 1. A source of compressed air 1 communicates with a nebulizer shown generally at 4 by way of a conduit 2. The flow of compressed air is controlled by valve 3. The nebulizer 4 contains a capillary tube 7 which extends down into the solution of growth hormone or cytokine in reservoir 8. The end of capillary 7 which is distal to solution reservoir 8 terminates immediately adjacent to the orifice 5 of conduit 2. An impaction sphere 6 is adjustably positioned opposite orifice 5. The orifice 5, capillary 7 and sphere 6 serve as the dispering means for forming the aerosol of the polypeptide disposed in reservoir 8. Nebulizer 4 also includes serrated output baffles shown generally at 9, downstream of which is a conduit 10 communicating with a respirator mouthpiece 12 for sealably engaging the mouth of the patient (not shown). The passage of aerosol 15 through conduit 10 is controlled by valve 11, which also operates valve 3 through circuit 13 and control device 14.

In operation, compressed air is valved by valve 3 on demand as determined by programmed control device 14. The control device is actuated on demand from valve 11. Compressed air passes through conduit 2 and out the orifice 5. The flow of air over the end of capillary 7 draws the solution of polypeptide from reservoir 8 into the stream of air where, together with collision on the impaction sphere 6, an aerosol of the solution is formed. The stable aerosol suspension is forced out by air pressure through baffles 9 and down conduit 10 upon demand from valve 11 as activated by the patient. The baffles are selected of appropriate size, dimension and composition to remove the bulk of particles greater than about 4µm. The seating of mouthpiece 12 will ensure that the patient inhales substantially only the delivered mixture of air and aerosolized polypeptide with each breath.

The method herein is illustrated by way of the following examples, which are not to be construed as limiting the invention.

Example 1

Intrapulmonary Delivery of met-hGH

An adult baboon weighing 24 kg was anesthetized with intravenous pentobarbital, a tracheal intubation performed and the animal allowed to breathe normally until and between dosing. A Bird Micronebulizer in line with Bird Mark 7 respirator was charged with 5-10 ml of a solution of 12 mg/ml Protropin^{R} brand of met-hGH (somatrem) in mannitol/phosphate buffer. The Micronebulizer then was used to simultaneously ventilate and dose the animal at 22 cm H_2O at a rate of 1.8 mg/hGH/-min. for 30 min. At this pressure the animal ventilated at approximately normal inspiratory volume. The animal was allowed to exhale normally after each ventilated breath and was positioned supine for dosing. After the first dosing period the animal was allowed to breathe normally for another 20 minutes, after which a second dosing was performed in the same way as the first. Blood plasma samples were taken at the initiation time of the first dose and thereafter as shown by the data points in Fig. 2. The baboon completely emerged from anesthesia 8 hours after the last pentobarbital injection. Radioimmunoassays of met-hGH in these sera showed that intrapulmonary delivery in accord herewith produced a blood level that is greater than twice that which is considered an acceptable therapeutic dose when administered intramuscularly. The radioimmunoassay employed in this example also will cross-react with normal baboon growth hormone, so it is believed that some of the hGH detected at 28 hours after the commencement of dosing may represent a circadian or stress induced increase in baboon growth hormone, probably similar to the levels in rhesus monkeys (10 ng/ml). Since the normal detectable GH levels in primates typically fall within the 10-20 µg/ml range, the method of this invention made it possible to deliver far in excess of a systemic therapeutically effective dose of hGH for a period exceeding 28 hours. This was particularly surprising since the general view is that long term drug delivery (>12 hr) is not achievable by intrapulmonary inhalation (Byron, op cit.).

Example 2

Intratracheal Instillation of Interferon or Tumor Necrosis Factor

Adult rats were anesthetized and tracheal intubations performed on each animal. Solutions of human recombinant gamma interferon and human recombinant tumor necrosis factor were injected into the trachea of test animals until a dosage of 3 mg/Kg and 378 mcg/Kg, respectively, was deliv-

ered. Serum samples were withdrawn from each test animal at the times indicated in Figs. 3-4 and assayed for the appropriate polypeptide. The results, shown in Figs. 3-4, clearly demonstrate effective system delivery of these two cytokines.

By means of the present invention it is possible to administer these polypeptides without the need for injections or infusions of certain polypeptides. This reduces the frequency of administration by providing sustained release from pulmonary tissue. It also enables therapeutically effective doses of the polypeptides to be delivered without therapeutically significant degradation of the polypeptides or the use of agents that lead to irritation of the bronchi, epithelium or other pulmonary tissue.

Claims

1. A device for delivering to the blood stream of a patient a therapeutic dose of a polypeptide selected from growth factors and cytokines, said device comprising reservoir means (8) for storing the polypeptide; a therapeutic dosage form of the polypeptide disposed in the reservoir means; dispersing means (4-7) for forming in a gas a suspension of particles comprising the polypeptide wherein greater than about 15% of the particles have a mean average diameter of about from 0.5 μm to 4 μm; means (1-3) for transporting the polypeptide to the dispersing means and means (9-12) for delivering the particle suspension to the alveoli of the patient's lungs.

2. The device of claim 1 wherein the proportion of particles having an average mean diameter larger then about 4 μm is less than about 25%.

3. The device of claim 1 or claim 2 wherein the polypeptide is somatropin, somatrem, interleukin 1, interleukin 2, tumor necrosis factor-α, tumor necrosis factor-β, a combination of tumor necrosis factor-α or tumor necrosis factor-β plus an interferon; or a combination of an interferon and interleukin-2.

4. The device of any one of claims 1 to 3 wherein the reservoir means (8) contains an aqueous solution of the polypeptide.

5. The device of any one of claims 1 to 3 wherein the reservoir means (8) contains a powder comprising the polypeptide suspended in a dry fluorocarbon.

6. The device of any one of claims 1 to 5 wherein the delivery means (12) is adapted to deliver the dose into the alveoli of the lungs without substantial contact with the nasal passages.

7. The device of claim 6 wherein the means for delivering the suspension to the alveoli is a mouthpiece (12) for sealably engaging the oral cavity.

8. The device of any one of claims 1 to 7 wherein the polypeptide is unaccompanied by an absorption enhancing agent.

9. A dispersion of polypeptide containing particles wherein greater than about 15% of the particles have a mean average diameter of about from 0.5 to 4 μm and wherein the polypeptide is selected from growth factors and cytokines.

10. The dispersion of claim 9 wherein the particles contain an aqueous solution of the polypeptide.

11. The dispersion of claim 10 wherein the dispersion is free of ether, antigens histamines, zinc oxide, methacholine, amphophilic steroids, chelating agents, bile salts or water-absorbing water-insoluble polymers in amounts sufficient to enhance absorption.

12. The dispersion of any one of claims 9 to 11 wherein about from 75 to 100% of the particles have a mean diameter of about from 0.5 to 4 μm.

13. The dispersion of any one of claims 9 to 12 wherein the particles are not liposomes or microcapsules.

14. The dispersion of any one of claims 9 to 13 wherein the particles are an aerosolized aqueous solution of the growth factor and/or cytokine.

15. The dispersion of claim 14 wherein the solution is substantially isotonic.

16. The dispersion of any one of claims 9 to 15 which is free of pulmonary irritants.

17. The dispersion of any one of claims 9 to 16 wherein the particles contain pulmonary surfactant.

Revendications

1. Dispositif pour délivrer dans le courant sanguin d'un patient une dose thérapeutique d'un polypeptide choisi entre des facteurs de croissance et des cytokines, ledit dispositif comprenant un réservoir (8) pour le stockage du polypeptide ; une forme posologique thérapeutique du polypeptide placé dans le réservoir ; des moyens de dispersion (4-7) pour la mise sous forme de gaz d'une suspension de particules comprenant le polypeptide, plus d'environ 15 % des particules ayant un diamètre moyen compris approximativement dans l'intervalle de 0,5 µm à 4 µm ; des moyens (1-3) pour le transport du polypeptide aux moyens de distribution et des moyens (9-12) pour délivrer la suspension de particules aux alvéoles des poumons du patient.

2. Dispositif suivant la revendication 1, dans lequel la proportion de particules ayant un diamètre moyen supérieur à environ 4 µm est inférieure à environ 25 %.

3. Dispositif suivant la revendication 1 ou la revendication 2, dans lequel le polypeptide est la somatotrophine, le somatrème, l'interleukine 1, l'interleukine 2, le facteur α de nécrose tumorale, le facteur β de nécrose tumorale, une association du facteur α de nécrose tumorale ou du facteur β de nécrose tumorale plus un interféron ; ou bien une association d'un interféron et d'interleukine 2.

4. Dispositif suivant l'une quelconque des revendications 1 à 3, dans lequel le réservoir (8) contient une solution aqueuse du polypeptide.

5. Dispositif suivant l'une quelconque des revendications 1 à 3, dans lequel le réservoir (8) contient une poudre comprenant le polypeptide mis en suspension dans un hydrocarbure fluoré anhydre.

6. Dispositif suivant l'une quelconque des revendications 1 à 5, dans lequel les moyens d'administration (12) sont aptes à délivrer la dose aux alvéoles des poumons sans un contact notable avec les voies nasales.

7. Dispositif suivant la revendication 6, dans lequel les moyens pour délivrer la suspension aux alvéoles consistent en un embout (12) destiné à être introduit de manière étanche dans la cavité buccale.

8. Dispositif suivant l'une quelconque des revendications 1 à 7, dans lequel le polypeptide n'est pas accompagné d'un agent accroissant l'absorption.

9. Dispersion de polypeptide contenant des particules, dans laquelle plus d'environ 15 % des particules possèdent un diamètre moyen d'environ 0,5 à 4 µm et dans laquelle le polypeptide est choisi entre des facteurs de croissance et des cytokines.

10. Dispersion suivant la revendication 9, dans laquelle les particules contiennent une solution aqueuse du polypeptide.

11. Dispersion suivant la revendication 10, qui est dépourvue d'un éther, d'antigènes, d'histamines, d'oxyde de zinc, de méthacholine, de stéroïdes amphophiles, d'agents chélatants, de sels biliaires ou de polymères insolubles dans l'eau et absorbant l'eau, en des quantités suffisantes pour accroître l'absorption.

12. Dispersion suivant l'une quelconque des revendications 9 à 11, dans laquelle approximativement 75 à 100 % des particules possèdent un diamètre moyen d'environ 0,5 à 4 µm.

13. Dispersion suivant l'une quelconque des revendications 9 à 12, dans laquelle les particules ne sont pas des liposomes ou des microcapsules.

14. Dispersion suivant l'une quelconque des revendications 9 à 13, dans laquelle les particules consistent en une solution aqueuse, transformée en un aérosol, du facteur de croissance et/ou de la cytokine.

15. Dispersion suivant la revendication 14, dans laquelle la solution est pratiquement isotonique.

16. Dispersion suivant l'une quelconque des revendications 9 à 15, qui est dépourvue d'irritants pulmonaires.

17. Dispersion suivant l'une quelconque des revendications 9 à 16, dans laquelle les particules contiennent un surfactant pulmonaire.

Patentansprüche

1. Vorrichtung zur Abgabe einer therapeutischen Dosis eines aus Wachstumsfaktoren und Zytokinen ausgewählten Polypeptids an den Blutkreislauf eines Patienten, wobei die genannte

Vorrichtung ein Reservoir (8) zum Speichern des Polypeptids; eine im Reservoir befindliche therapeutische Dosierungsform des Polypeptids; Dispergiereinrichtungen (4-7) zum Bilden einer Teilchensuspension, welche das Polypeptid umfaßt, in einem Gas, worin mehr als etwa 15% der Teilchen einen mittleren Durchmesser etwa von 0,5 µm bis 4 µm aufweisen; Einrichtungen (1-3) zum Transportieren des Polypeptids zur Dispergiereinrichtung und Einrichtungen (9-12) zum Zuführen der Teilchensuspension zu den Alveolen der Lunge des Patienten umfaßt.

2. Vorrichtung nach Anspruch 1, worin der Anteil an Teilchen mit einem mittleren Durchmesser über etwa 4 µm weniger als etwa 25% beträgt.

3. Vorrichtung nach Anspruch 1 oder 2, worin das Polypeptid Somatropin, Somatrem, Interleukin 1, Interleukin 2, Tumornekrosefaktor-β, Tumornekrosefaktor-β, eine Kombination aus Tumornekrosefaktor-β oder Tumornekrosefaktor-β plus einem Interferon, oder eine Kombination aus einem Interferon und Interleukin-2 ist.

4. Vorrichtung nach einem der Ansprüche 1 bis 3, worin das Reservoir (8) eine wäßrige Lösung des Polypeptids enthält.

5. Vorrichtung nach einem der Ansprüche 1 bis 3, worin das Reservoir (8) ein Pulver enthält, welches das in einem trockenen Fluorkohlenwasserstoff suspendierte Polypeptid enthält.

6. Vorrichtung nach einem der Ansprüche 1 bis 5, worin die Abgabeeinrichtung (12) zum Zuführen der Dosis in die Alveolen der Lunge ohne wesentlichen Kontakt mit den Nasendurchgängen ausgebildet ist.

7. Vorrichtung nach Anspruch 6, worin die Abgabeeinrichtung für die Suspension an die Alveolen ein Mundstück (12) zum dicht abschließbaren Eingreifen in die Mundhöhle ist.

8. Vorrichtung nach einem der Ansprüche 1 bis 7, worin das Polypeptid nicht von einem absorptionssteigernden Agens begleitet ist.

9. Teilchen enthaltende Polypeptiddispersion, worin mehr als etwa 15% der Teilchen einen mittleren Durchmesser etwa von 0,5 bis 4 µm aufweisen und worin das Polypeptid aus Wachstumsfaktoren und Zytokinen ausgewählt ist.

10. Dispersion nach Anspruch 9, worin die Teilchen eine wäßrige Lösung des Polypeptids enthalten.

11. Dispersion nach Anspruch 10, worin die Dispersion frei von Äther, Antigenen, Histaminen, Zinkoxid, Methacholin, amphophilen Steroiden, chelatbildenden Agenzien, Gallensalzen oder wasserabsorbierenden wasserunlöslichen Polymeren in Mengen, die ausreichen, um die Absorption zu verstärken, ist.

12. Dispersion nach einem der Ansprüche 9 bis 11, worin etwa von 75 bis 100% der Teilchen einen mittleren Durchmesser etwa von 0,5 bis 4 µm aufweisen.

13. Dispersion nach einem der Ansprüche 9 bis 12, worin die Teilchen keine Liposome oder Mikrokapseln sind.

14. Dispersion nach einem der Ansprüche 9 bis 13, worin die Teilchen eine in Aerosolform gebrachte wäßrige Lösung des Wachstumsfaktors und/oder Zytokins sind.

15. Dispersion nach Anspruch 14, worin die Lösung im wesentlichen isotonisch ist.

16. Dispersion nach einem der Ansprüche 9 bis 15, die frei von pulmonalen Reizstoffen ist.

17. Dispersion nach einem der Ansprüche 9 bis 16, worin die Teilchen pulmonales Tensid enthalten.

Fig.1.

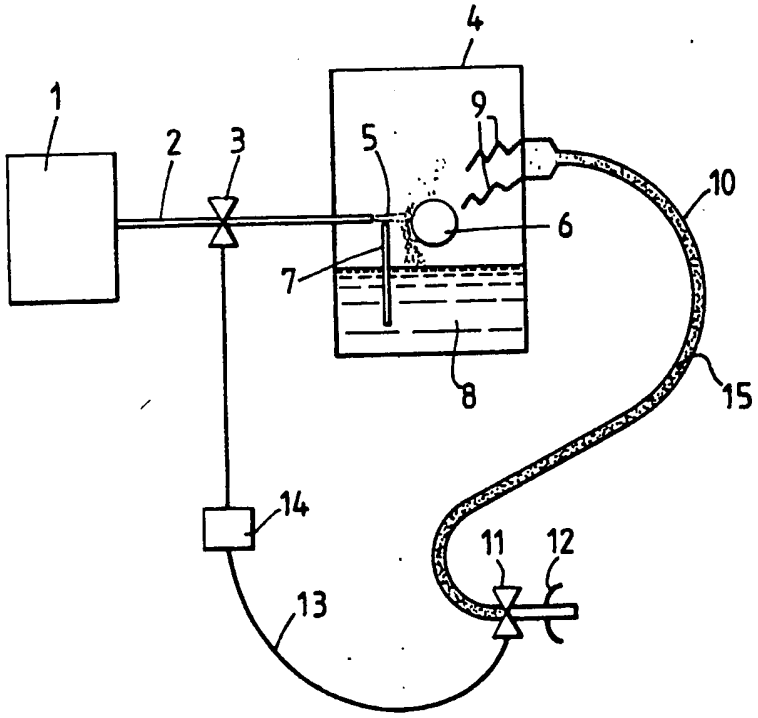
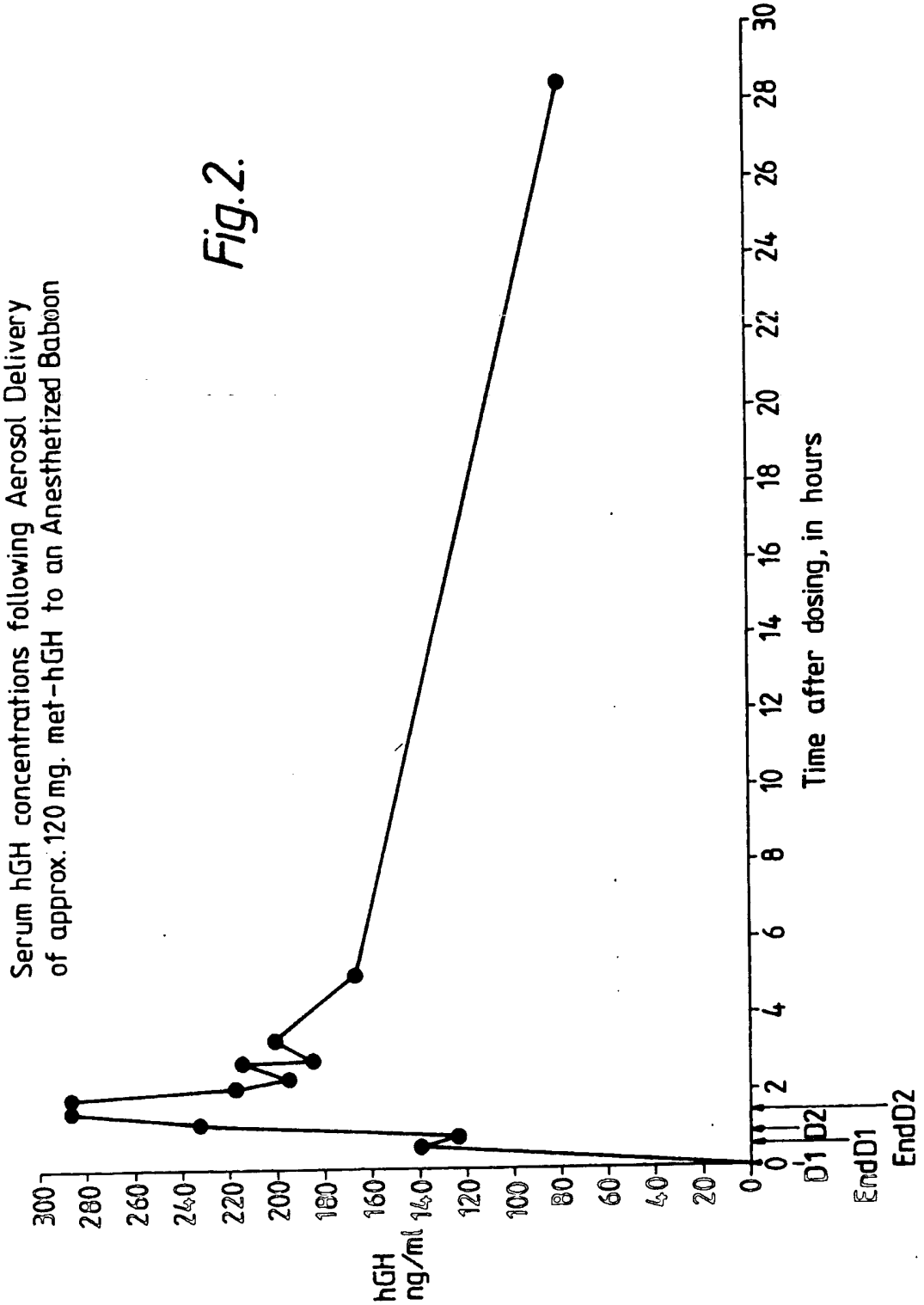


Fig.2.


Serum hGH concentrations following Aerosol Delivery
of approx. 120 mg. met-hGH to an Anesthetized Baboon
hGH ng/ml
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
D1
D2
EndD1
EndD2
Time after dosing, in hours

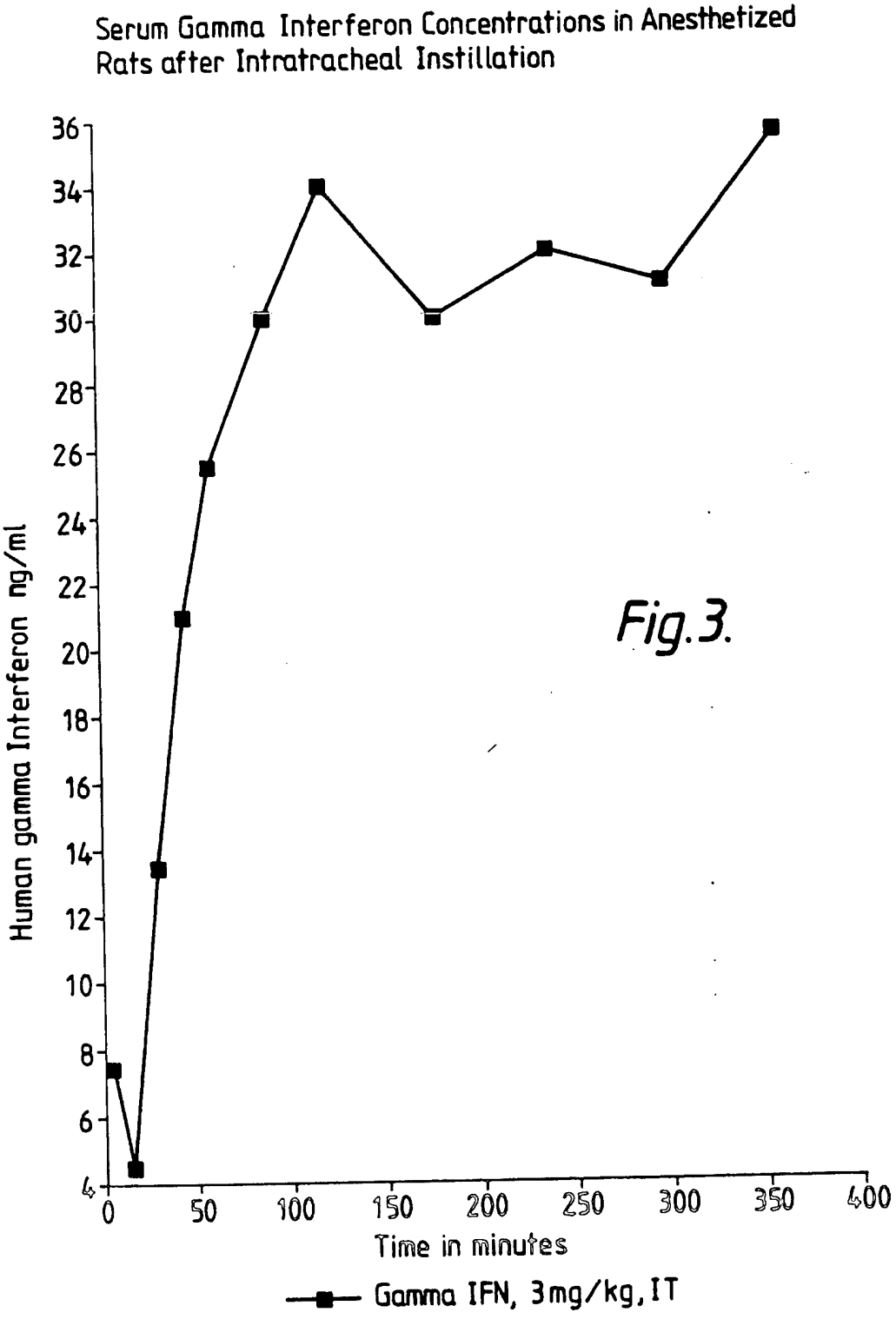

Serum Gamma Interferon Concentrations in Anesthetized Rats after Intratracheal Instillation
Human gamma Interferon ng/ml
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
0
50
100
150
200
250
300
350
400
Time in minutes
Gamma IFN, 3mg/kg, IT

Fig.3.

Serum TNF Concentrations in Anesthetized Rats
after Intratracheal Instillation
n=6, except at t= 300 min. (n=3)

Fig. 4.